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Inside this issue:

Ground-breaking research could challenge underlying principles of physics

An international team of physicists, including a Plymouth University academic, has published ground-breaking research on the decay of subatomic particles called kaons – which could change how scientists understand the formation of the universe.

Dr Nicolas Garron, a Research Fellow in the Centre of Mathematical Sciences, has helped to devise the first theoretical calculation of how the behaviour of kaons differs when matter – anything with mass, such as the world around us – is swapped out for antimatter – made out of similar particles with opposite charge.

The calculation of the kaon decays was conducted on supercomputers, which would have taken 200 million core processing hours on a laptop. So why is the calculation important?

The rate at which the kaons decay highlights that, despite being virtually identical, there is an asymmetry between matter and antimatter. This is key to physicists' understanding of the universe, as it's currently accepted that the universe was created with equal parts of matter and antimatter, and, in order for matter to have overhauled its negative counterpart, the two sets of particles must have behaved differently – however slight that difference was.

Nobel prize-winning work dating back to 1964 first showed that matter and antimatter are asymmetrical, a concept known as indirect CP violation. This was built upon to a more accurate degree in 2000, to uncover direct ...Read More...

Gravity, who needs it

What happens to your body in space? NASA's Human Research Program has been unfolding answers for over a decade. Space is a dangerous, unfriendly place. Isolated from family and friends, exposed to radiation that could increase your lifetime risk for cancer, a diet high in freeze-dried food, required daily exercise to keep your muscles and bones from deteriorating, a carefully scripted high-tempo work schedule, and confinement with three co-workers picked to travel with you by your boss.

Scott Kelly will be the first American to spend nearly one year in space aboard the International Space Station, twice the normal time. Researchers are eagerly awaiting results of the mission to see how much more the body changes after a year in space. One year is a stepping stone to a three-year journey to Mars, and Scott's data will help researchers determine whether the solutions they've been developing will be suitable for such long, onerous journeys.

But what, exactly, happens to your body in space, and what are the risks? Are risks the same for six months on the space station versus three years on a Mars mission? No. There are several risks NASA is researching for a Mars mission. The risks are grouped into five ...Read More….

File image: Scott Kelly.

A new symmetry underlies the search for new materials

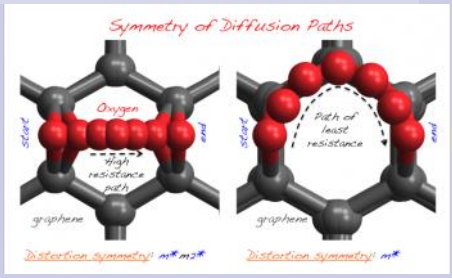
A new symmetry operation developed by Penn State researchers has the potential to speed up the search for new advanced materials that range from tougher steels to new types of electronic, magnetic, and thermal materials. With further developments, this technique could also impact the field of computational materials design.

"In the physical sciences, making measurements can be time consuming and so you don't want to make unnecessary ones," said Venkat Gopalan, professor ofmaterials science and engineering. "This is true for any material property—mechanical, electrical, optical, magnetic, thermal or any other. Knowing the symmetry group of a material can greatly reduce the number of measurements you have to make. "

Symmetry is pervasive throughout the physical universe and underlies the basic laws of physics. Gopalan gives a simple but scientifically accurate definition. "Symmetry is when doing something looks like doing nothing."

A circle has perfect symmetry, because if you rotate it by any number of degrees, it will look the same. Similarly, rotating a hexagon by sixty degrees leaves it exactly the same, but rotating it by a different amount does not. Anything that can be done that leaves an object looking the same is a symmetry operation.

In crystals, atoms are arranged in symmetrical patterns, like a cube of salt or a crystal of sugar or quartz. Symmetry groups tell scientists in how many different ways atoms can arrange in repeating patterns. If they know which ...Read More….



Each diffusion path for an oxygen atom (red) moving across a graphene ring composed of carbon atoms (gray) is considered a 'distortion' and is indexed by a unique 'distortion symmetry group' indicated below each image. The symmetry group contains all the essential information about the properties of the material system as the diffusion occurs, including the ability to help determine the minimum energy pathway. In this case, the minimum energy pathway is when oxygen moves around the ring (right image) rather than across it (left image). Credit: Venkat Gopalan, Penn State

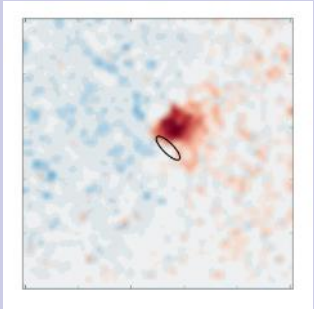
X-ray microscope reveals 'solitons,' a special type of magnetic wave

Researchers used a powerful, custom-built X-ray microscope at the Department of Energy's SLAC National Accelerator Laboratory to directly observe the magnetic version of a soliton, a type of wave that can travel without resistance. Scientists are exploring whether such magnetic waves can be used to carry and store information in a new, more efficient form of computer memory that requires less energy and generates less heat.

Magnetic solitons are remarkably stable and hold their shape and strength as they travel across a magnetic material, just as tsunamis maintain their strength and form while traversing the ocean. This offers an advantage over materials used in modern electronics, which causes them to heat up.

In experiments at SLAC's Stanford Synchrotron Radiation Lightsource, a DOE Office of Science User Facility, researchers captured the first X-ray images of solitons and a mini-movie of solitons that were generated by hitting a magnetic material with electric current to excite rippling magnetic effects. Results from two independent experiments were published Nov. 16 in Nature Communicationsand Sept. 17 in Physical Review Letters.

"Magnetism has been used for navigation for thousands of years and more recently to build generators, motors and data storage devices," said co-author Hendrik Ohldag, a scientist at SSRL. "However, magnetic elements were ..Read More...



An ultrafast camera coupled to a custom-built X-ray microscope at SLAC's Stanford Synchrotron Radiation Lightsource allowed researchers to produce a six-frame "movie" of the soliton's motion. It took about 12 hours to record enough X-ray data to produce the movie. Credit: Stefano Bonetti/Stockholm University

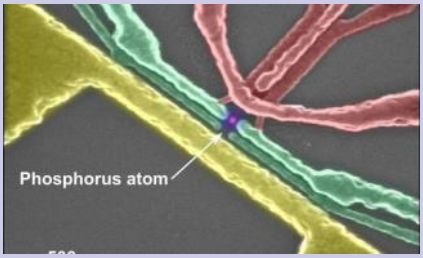
Quantum computer coding in silicon now possible

A team of Australian engineers has proven—with the highest score ever obtained—that a quantum version of computer code can be written, and manipulated, using two quantum bits in a silicon microchip. The advance removes lingering doubts that such operations can be made reliably enough to allow powerful quantum computers to become a reality.

The result, obtained by a team at Australia's University of New South Wales (UNSW) in Sydney, appears today in the international journal, Nature Nanotechnology.

The quantum code written at UNSW is built upon a class of phenomena called quantum entanglement, which allows for seemingly counterintuitive phenomena such as the measurement of one particle instantly affecting another - even if they are at opposite ends of the universe.

"This effect is famous for puzzling some of the deepest thinkers in the field, including Albert Einstein, who called it 'spooky action at a distance'," said Professor ...Read More…



False-colour electron microscope image of the silicon nanoelectronic device which contains the phosphorus atom used for the demonstration of quantum entanglement. Credit: University of New South Wales

Tyson weighs in on New Horizons' Pluto discoveries

The New Horizons spacecraft completed its 3 billion mile journey to Pluto in July and the discoveries continue to pour in every week as NASA scientists receive and analyze data and images from the flyby. It will be another year before scientists on Earth receive the last of the data cache from the decade-long mission.

Some of the dozens of recent discoveries were shared last week at the 47th Annual Meeting of the American Astronomical Society's Division for Planetary Sciences. Of note was evidence that two of Pluto's highest mountains may be recently active cryovolcanos, or ice volcanoes. Instead of spewing lava and magma like Earth's volcanoes, they erupt a melted cocktail of water ice, nitrogen, ammonia or methane particles. And there are other aspects of Pluto's surface features that tell a compelling story about its past.

The age of a planet's surface area directly correlates to the number of impact craters. By counting thousands of impact craters, New Horizons scientists have found regions ranging in age from 4 billion years to a freshly-formed 10 million years old, indicating that the dwarf planet has been alive with geological activity throughout much of its existence.

The most publicized (and perhaps romanticized) discoveries, announced last month, are water-ice deposits on the surface and a stunning blue sky reminiscent of Earth's own atmosphere.

Astrobiology Magazine sat down with astrophysicist and Hayden Planetarium director Neil deGrasse Tyson to get his take on these findings. He's the author of The Pluto Files and a famed accomplice in the ...Read More...

"Pluto's Blue Sky: Pluto's haze layer shows its blue color in this picture taken by the New Horizons Ralph/Multispectral Visible Imaging Camera (MVIC). The high-altitude haze is thought to be similar in nature to that seen at Saturn's moon Titan. The source of both hazes likely involves sunlight-initiated chemical reactions of nitrogen and methane, leading to relatively small, soot-like particles (called tholins) ….

UA researchers capture first photo of planet in making

There are 450 light-years between Earth and LkCa15, a young star with a transition disk around it, a cosmic whirling dervish, a birthplace for planets. Despite the disk's considerable distance from Earth and its gaseous, dusty atmosphere, University of Arizona researchers captured the first photo of a planet in the making, a planet residing in a gap in LkCa15's disk.

Of the roughly 2,000 known exoplanets - planets that orbit a star other than our sun - only about 10 have been imaged, and that was long after they had formed, not when they were in the making.

"This is the first time that we've imaged a planet that we can say is still forming," says Steph Sallum, a UA graduate student, who with Kate Follette, a former UA graduate student now doing postdoctoral work at Stanford University, led the research. The researchers' results were published in Nature.

Only months ago, Sallum and Follette were working independently, each on her own Ph.D. project. But serendipitously they had set their sights on the same star. Both were observing LkCa15, which is surrounded by ...Read More...

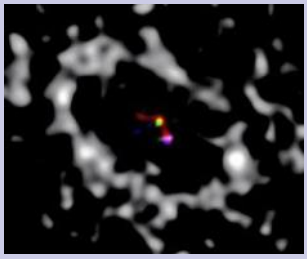


Image shows a composite where blue represents the MagAO data taken at H-alpha, and green and red show the LBT data taken at Ks and L' bands. The greyscale is a previously published millimeter image of the disk. Image courtesy Stephanie Sallum.

ALMA links with other observatories to create Earth-sized virtual telescope

The Atacama Large Millimeter/submillimeter Array (ALMA) continues to expand its power and capabilities by linking with other millimetre-wavelength telescopes in Europe and North America in a series of very long baseline interferometry (VLBI) observations.

In VLBI, data from two or more telescopes are combined to form a single, virtual telescope that spans the geographic distance between them. The most recent of these experiments with ALMA and other telescopes formed an Earth-sized telescope with extraordinarily fine resolution.

These experiments are an essential step in including ALMA in the Event Horizon Telescope (EHT), a global network of millimetre-wavelength telescopes that will have the power to study the supermassive black hole at the centre of the Milky Way in unprecedented detail.

Before ALMA could participate in VLBI observations, it first had to be transformed into a different kind of instrument known as a phased array. This new version of ALMA allows its 66 antennas to function as a single radio dish 85 metres in diameter, which then becomes one element in a much larger VLBI telescope.

The first test of ALMA's VLBI capabilities occurred on 13 January 2015, when ALMA successfully linked with the Atacama Pathfinder Experiment Telescope (APEX), which is about two kilometres from the centre of the ALMA array.

On 30 March 2015, ALMA reached out much further by linking with the Institut de Radioastronomie Millimetrique's ...Read More...

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ISS EarthKAM ready for student imaging request

This week saw the return of an investigation on the International Space Station inspired by the first American woman in space, connecting students on Earth with a camera in space. The orbiting laboratory has proven to be a valuable platform for Earth observation, circling the Earth approximately 230 miles overhead once every 90 minutes. This vantage point not only provides good images for working scientists, but for the budding scientist as well.

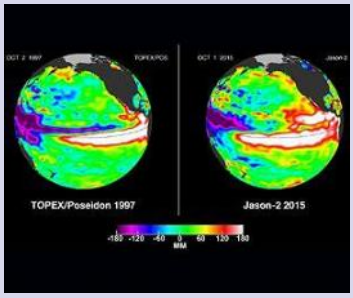
Roscosmos (Russian Federal Space Agency) cosmonaut Mikhail Kornienko completed setting up the Sally Ride Earth Knowledge Acquired by Middle School Students (Sally Ride EarthKAM) camera for the program's autumn 2015 session on the space station. The Sally Ride EarthKAM program - created by the veteran astronaut who was America's first woman in space - allows students to request photographs of specific Earth features when the station passes over that area….Read More...

This image was taken during the November 2015 run of the Sally Ride EarthKAM aboard the International Space Station. Students on Earth programmed the camera aboard the orbiting laboratory to snap pictures around the globe. Image courtesy NASA/EarthKAM.org.

2015 and 1997 El Ninos: Deja vu, or Something New

If you live anywhere El Nino has important impacts, you've heard forecasters say this year's event looks just like the monster El Nino of 1997-98. NASA satellite images of the Pacific Ocean in November 1997 and November 2015 show almost identical, large pools of warm water in the eastern equatorial Pacific. The National Weather Service has forecast that impacts this winter will resemble those in 1997, when California and the South suffered floods, mudslides and tornadoes, while residents of the Upper Midwest saved $2 billion to $7 billion in heating costs throughout their unusually warm winter.

When it comes to El Ninos, however, there are no identical twins. This year's event hasn't always resembled the '97 one. Satellite observations from early '97 and early '15 show conditions in the Pacific Ocean that were, well, oceans apart. In its "normal" state, the Pacific is warm on the western side and cooler in the east. ...Read More...



In this side-by-side visualization, Pacific Ocean sea surface height anomalies during the 1997-98 El Nino (left) are compared with 2015 Pacific conditions (right). The 1997 data are from the NASA/CNES Topex/Poseidon mission; the current data are from the NASA/CNES/ NOAA/EUMETSAT Jason-2 mission. Image courtesy NASA/JPL-Caltech.

Dark matter might cause fundamental constants to change over time

The fundamental constants of nature—such as the speed of light, Planck's constant, and Newton's gravitational constant—are thought to be constant in time, as their name suggests. But scientists have questioned this assumption as far back as 1937, when Paul Dirac hypothesized that Newton's gravitational constant might decrease over time….Read More...

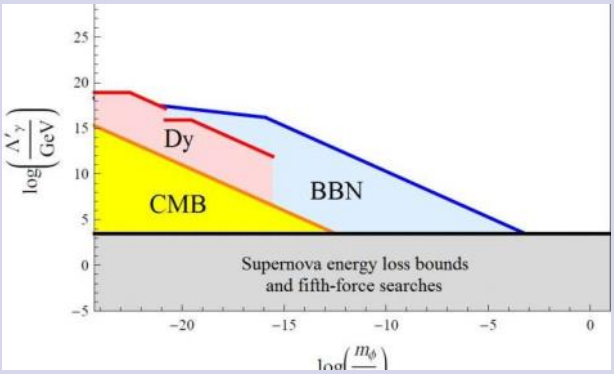


Figure showing the limits on the interaction strength between dark matter and standard model particles such as photons, electrons, and quarks. In the present work, the researchers greatly improved these limits by deriving constraints from the helium abundance during big bang nucleosynthesis (BBN), spectroscopy measurements of the rare element dysprosium (Dy), and measurements of the cosmic microwave background (CMB). Previous research has derived constraints from supernova data and fifth-force searches. Credit: Stadnik and Flambaum. ©2015 American Physical Society